This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

QL
378
.T69

B 486885

h. Lab. 593.6 T

Torrey, H. B.

Observations on
Monogenesis in
Metridium

GENERAL LIBRARY
OF
UNIVERSITY OF MICHIGAN
PRESENTED BY
S. J. Holmes
May 18 1900

Morph Lab
SCIENCE LIBRARY
QL
378
.T69

Full ol pain. Gr 5-5 morph lab

From Mr. S. J. Holmes

GENERAL LIBRARY,
UNIV. OF MICH.
MAY 18 1900

PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES.

THIRD SERIES.

ZOOLOGY. VOL. I, NO. 10.

Observations on Monogenesis in Metridium.

BY

HARRY BEAL TORREY.

WITH ONE PLATE.

Issued October 25, 1898.

SAN FRANCISCO:
PUBLISHED BY THE ACADEMY.
1898.

OBSERVATIONS ON MONOGENESIS IN METRIDIUM.

BY HARRY BEAL TORREY.

CONTENTS.

PAGE.

PLATE XXI.

I. INTRODUCTION 345
II. LONGITUDINAL FISSION 347
  (a.) *Equal* 347
  (b.) *Unequal* 347
III. BASAL FRAGMENTATION 352
IV. BUDDING 353
  (a.) *Pedal* 353
  (b.) *Œsophageal* 354
V. COLONIES OF THREE AND FOUR INDIVIDUALS 356
VI. SUMMARY 357
BIBLIOGRAPHY 359
EXPLANATION OF PLATE 360

Reclass 12-8-38

I. INTRODUCTION.

THE MATERIAL for this investigation was furnished by *Metridium fimbriatum* Verrill, an extremely abundant species in the harbor of Oakland, Cal. It is practically identical, according to Verrill, 1868, with *M. marginatum* of the eastern coast, and *M. dianthus* of Europe; these three species being distinguished without doubt solely on account of their wide separation geographically.

The animals were found crowded together in great numbers upon the piles supporting the two railroad bridges which cross the estuary. They range as high as three feet above mean low-water mark. The water is brackish, and at ebb tide is exceedingly dirty. They are quite hardy and may be kept indefinitely in aquaria. Several specimens have been in captivity since October, 1897; yet they are not so vigorous as they were in their natural environment. The change in their conditions of life has probably served to retard the processes of asexual reproduction described hereafter.

Oct. 20, 1898.

Tullberg's method of killing and hardening anemones for macro-sectioning, as recommended by Parker, 1897, gave satisfactory results. Magnesium sulphate in strong solution was added to the water containing the animals until they were thoroughly narcotized. They were then placed in a one per cent. solution of chromic acid for several hours. Serial sections were usually taken with a razor, a method which showed satisfactorily, among all but the smallest specimens, the arrangement and behavior of the mesenteries, mesenterial muscles, and siphonoglyphs. The smallest specimens were sectioned on the microtome.

In the latter part of September, 1897, a large specimen of *Metridium fimbriatum* was brought to the laboratory. Upon expansion it was found to have divided partially into three individuals. There were two complete circlets of tentacles, one of which enclosed two mouths, the other but one. The oral disks had but just separated. No trace of division existed beyond the parapet.

More monogenous polyps were found in small numbers in the months of October, November, January to June inclusive. At present I am unable to say whether they are in greater abundance during some seasons than others. Among 1971 polyps collected at random in May and June, 48 (2.43 per cent.) were monogenous. The diameter of the column when well expanded varied from 2 to 30 mm Sexual elements may be present.

Three modes of monogenesis have been observed:—

1. Longitudinal fission.
    - *a.* Equal.
    - *b.* Unequal.
        - Oral-aboral.
        - Aboral-oral.
2. Basal fragmentation.
3. Budding.
    - *a.* Pedal.
    - *b.* Œsophageal.

No case of transverse fission (Agassiz 1865) has as yet come under my notice.

II. LONGITUDINAL FISSION.

(*a.*) *Equal.*—The equality here is only approximate. No perfectly equal fission has been observed, which is hardly to be wondered at in such a variable genus as *Metridium.*

Three cases of equal fission have been seen. The best example is shown in section in fig. 1. This figure is drawn to show the arrangement of the mesenteries and siphonoglyphs in the œsophageal region, looking toward the mouths from within. The six mesenteries diverging from *B*, three running to each œsophagus, and the two mesenteries, one bearing a mesenterial filament, which run between the two œsophagi, are below the plane of the section.

While the symmetry is not absolute, it is still striking. At *D* and *D'* are the two pairs of directives, indicating the siphonoglyphs, symmetrically placed to the plane of division passing through *A–B*. There are eleven pairs of complete mesenteries symmetrically placed with respect to the plane of division; five pairs to each œsophagus, and one pair divided, one member going to each œsophagus. The incomplete mesenteries comprised between every two adjacent pairs of symmetrically placed complete mesenteries are, with the exception of the two sections 1–2 and 1'–2', remarkably symmetrical for such a variable species.

(*b.*) *Unequal.*—This is the usual mode of division. Its later stages cannot always be distinguished with certainty from budding. Fifteen undoubted cases have been observed. The progress of the division is as a rule from the oral toward the foot disk. One specimen has been taken, however, which was dividing in the reverse direction, as described by McCrady, 1858, for *A. cavernosa.* The foot disk had divided completely, and the plane of division had parted the column for one-third of its length. The animal died soon after its capture, which prevented dissection.[1]

---

[1] Since this was written, the pedal disk of a polyp in the laboratory was accidentally torn into two portions. These, upon healing of the surfaces of the wound, have remained distinct, two apparently well-formed pedal disks being the result. The exception mentioned in the text may have been due to a similar cause.

Seven cases were dissected, each in a stage shortly after the division of the mouth. In but one had the mouth divided transversely (fig. 2.) The single siphonoglyph, lying at one end of the mouth, was therefore not included in the division, but remained intact as the siphonoglyph of the larger œsophagus. There was no sign of a siphonoglyph upon the other mouth.

In each of the other six cases the division plane had passed through the greater axis of the mouth, dividing the siphonoglyph into two portions, one pertaining to each of the two new œsophagi. Figure 3 shows the siphonoglyph dividing, slightly in advance of the division of the œsophagus. Figure 3*a* is toward the aboral end of the œsophagus; neither siphonoglyph nor œsophagus has divided. Figure 3*b* is a section taken nearer the oral disk; the siphonoglyph here exhibits a median fold marking the line of division, and the œsophagus is constricting longitudinally. A section taken above the point of junction of the two newly formed œsophagi is shown in fig. 3*c*; the siphonoglyph has divided, and each portion, by the division of the primary pair of directives, possesses but one directive mesentery. The plane of division has passed between the members of pair *m*, also, so that each œsophagus (3*c*) obtains one mesentery.

A similar case is shown in figs. 4*a* and 4*b*, which are drawn from a diglyphic polyp with an unusually large number of complete mesenteries. But one siphonoglyph is affected by the division; so that the smaller derivative œsophagus possesses two siphonoglyphs, the larger, one. The mesenteries of the pair of directives *D*, and non-directives *m* are apportioned as in the preceding case. This separation of the members of a pair is characteristic of longitudinal fission.

Somewhat later stages are shown in figs. 5 and 6, in each of which the derivative œsophagi are distinct throughout their length. While the siphonoglyphs in each polyp are entirely separated, they are still closely related in position; and the directives exhibit the divergence characteristic of the division in the first two cases. The remaining two cases were essentially similar to that shown in fig. 3*c*, though more nearly equally divided. Figure 4 represents a diglyphic polyp. Figure 6 in all probability represents the result of the division of another diglyphic polyp. This is an unique case. The plane of division seems to have passed through both siphonoglyphs of the original polyp, as indicated by the division of the two pairs of directives. The siphonoglyphs, immediately upon their division, were probably approximated by the longitudinal constriction of the œsophagus which usually follows the division of a siphonoglyph. Opposite halves of the divided siphonoglyphs could then unite by their inner edges to form the two derivative siphonoglyphs, one on either side of the plane of division.

There are reasons for believing that this method of division so plainly exhibited in the foregoing six cases is the usual one. In each of the eight remaining cases of longitudinal fission (excepting the single instance of division transversely to the mouth) there is a marked symmetry in the position of the siphonoglyphs with respect to the plane of division. This has been alluded to already in connection with fig. 1, where the greater axes of the mouths, passing through the siphonoglyphs, form with the plane of division angles of 25 degrees. In fig. 7 these angles are about 15 degrees; in fig. 8, 45 degrees. In five other specimens the angles are respectively 45, 35, 35, 15, 0 degrees.

The smallness of these angles suggests the conclusion that each pair of diverging siphonoglyphs has arisen from a single siphonoglyph by longitudinal fission. This conclusion is supported by the conditions found in figs. 7 and 8. The triglyphic type is exceedingly rare, two instances having been counted among 451 individuals. This decidedly lessens the probability that these two cases were originally triglyphic polyps. Moreover, each could be derived from fig. 4 by the completion of the directives and the introduction of two pairs of non-directives between the pairs of directives. Such cases as the one represented in fig. 1

could be derived from fig. 3*c* by the completion of the directives and the interposition of two pairs of non-directives between the directives. Although these assumptions cannot at present be fully tested, they yet receive considerable support from the facts that a single *Metridium* is never found with an incomplete pair of directives; and that the two mesenteries of a pair frequently vary, independently of each other, in breadth (pair *i*, fig. 3). In a case of budding, to be mentioned again later, the bud, having received but one directive mesentery from the parent, had grown a second to complete the pair. It is probable, then, that complete mesenteries have arisen, after the division of the siphonoglyphs, between the pairs of directives (figs. 1, 7, 8).

Further investigation only can establish the relative frequency of those divisions which include the siphonoglyph to the total number. But it seems fair to conclude that since the plane of division of 40 per cent. of the total number of dividing polyps examined has passed through at least one siphonoglyph, there exists in *Metridium* a predisposition to divide in this manner.

Division, then, in *Metridium*, is probably initiated by a longitudinal splitting of a siphonoglyph. A constriction of the mouth follows, resulting in the formation of two mouths in the place of the one, each mouth obtaining a portion of the original siphonoglyph. The division plane usually proceeds aborally, and may almost completely sever the two portions of the œsophagus before any constriction becomes apparent in the oral disk. An irregular line of tentacles grows in between the two mouths; the constriction of the oral disk, proceeding inward, gradually separates these into two series, dividing the oral disk into two parts. The parapet next divides by means of a similar constriction. A longitudinal groove on each side of the column now marks the course of the division plane; and at about this stage the mesenteries of the foot disk (which is semitransparent) are seen to be arranged about two centers of radiation. I have not been able to follow this rearrangement. The furrow between the newly formed oral disks gradually deepens.

The rate of fission is exceedingly slow, for I have not observed a single instance of full severence of individuals, though a number of dividing polyps have been kept in the laboratory for nine months. The artificial conditions of the aquaria may serve as a retarding factor.

Some of the divisions are of marked inequality. In one case three perfect pairs (*i. e.*, in which both mesenteries reach the œsophagus) and two half-pairs of complete mesenteries radiate from one œsophagus, nine perfect and three half-pairs from the other; total, fifteen pairs. In fig. 3*c* five complete mesenteries reach one œsophagus, ten the other; total, eight pairs. Mesentery *i*, incomplete in fig. 3*a* and 3*b*, finally reaches the œsophagus in fig. 3*c*. In fig. 8 the siphonoglyphs are unequally apportioned: the œsophagus with two siphonoglyphs possesses two and one-half pairs of non-directives, the monoglyphic œsophagus, five and one-half pairs of non-directives; total number of complete mesenteries, eleven pairs. In fig. 4, fifteen mesenteries reach the diglyphic, thirty-one the monoglyphic œsophagus; total, twenty-one perfect pairs, four unpaired, or imperfect pairs. Figures 5 (thirteen pairs) and 6 (eleven pairs) exhibit striking inequalities in apportionment of mesenteries between the two œsophagi. In fig. 7, six of a total of eleven pairs reach one œsophagus, five the other. In another case, eleven and one-half pairs are distributed as equally as possible to the two œsophagi. So great are the discrepancies in number and distribution of mesenteries in these cases, that no definite relation between monogenesis and the number and position of mesenteries can be asserted.

Advanced stages of unequal fission may be distinguished from budding usually by an external examination only, if the polyp be living. The bases of the mesenteries are readily seen as dark lines through the semitransparent walls. In fig. 9 is represented a plan of the mesenteries in the angle between the two individuals of a dividing polyp, seen from above. Only two pairs of mesenteries from *A* run into pairs from *B*. These form two *Y's*, the stalks of which run down the sides of the common column. All the other mesenteries in each polyp remain distinct from those of the other throughout their length. This is a condition one would expect to meet in a case of fission, but not in budding, as will be shown later.

III. BASAL FRAGMENTATION.

Laccration.—This process has been described for two species of *Aiptasia* and one species of *Bunodes*, by Andres, 1882. Several cases have come under my notice. On March 29, 1898, two small fragments of a pedal disk were found attached to the side of a dish in which several anemones were kept. On April 5th, one of the fragments had disappeared, the other had rounded itself up into the shape of a contracted individual, and possessed a few tentacles. A few days later it had become an apparently well formed individual. The cavity in the fragment was a portion of the cavity of the original polyp from which the fragment came.

On April 5th, the *Metridium* obtained on September 27th, which was in process of division into three individuals, was found with a gaping wound in the base of the column and foot disk. The large fragment which had been torn from it was near by. It rounded itself up as the others had done. By April 23rd, it had produced two individuals which remained connected by a common base; they had probably arisen independently as buds. By the use of sections their mesenterial systems were seen to be entirely distinct. One individual was diglyphic, the other monoglyphic. There was no sign of a previous connection between any two of these; the directives were distinct throughout. There were six and one-half pairs of complete mesenteries in one individual, six complete and two pairs of incomplete mesenteries in the other. Their arrangement in the latter was according to the formula:—

$$D\text{–}2\text{–}D'\text{–}4\text{–}5\text{–}6/2\text{–}7\text{–}8/2.$$

D and D' are the directives. The asymmetry of their positions is noteworthy. It should be noted also that the polyp from which this fragment came was sexually mature and was itself dividing.

One case of this laceration was observed in a polyp in its natural environment. All the others occurred in aquaria, where the conditions were not so favorable. This unfavorable environment may have had some influence in initiating this method of reproduction which was not begun by certain polyps until they had been in captivity for more than six months, when fragments were thrown off, occasionally three or four at a time.

IV. BUDDING.

Buds may occur either upon the upper surface of the expanded foot disk or in the region of the œsophagus. In the first case, the bud is always, relatively to the parent, very small, and its œsophagus and siphonoglyph are formed independently of the corresponding structures of the parent. In the second, the bud may almost equal the parent in size; its œsophagus arises from the œsophagus of the parent; its siphonoglyph may be independent of the siphonoglyph of the parent from the beginning, or the siphonoglyph of the parent may enter the bud, in which case the bud possesses two instead of one.

(*a.*) *Pedal—Budding from foot region.*—Seven polyps have been taken with these marginal buds. In one of these cases the bud has broken away from the parent; in another the process of division is advanced; in the others it has not yet begun, although the polyps have been under observation for several months.

In the earliest stage seen, the bud was a small rounded protuberance near the edge of the foot disk. In the course of preparation for sectioning it was lost. All the other specimens were in an advanced stage and bore tentacles when collected.

The rate of detachment is low, to judge from observations taken in the laboratory, where the conditions are not favorable. The only bud which has become free in the laboratory aquaria was taken March 30th. On April 5th it was seen to be detaching. The expansion of the foot disk on which it rested was exceedingly flat and formed a decided lobe connected by an isthmus of about half its diameter with the parent. The walls of the lobe were quite thin, enclosing a portion of the cavity of the parent. On April 14th the only change was a greater attenuation of the connecting isthmus. On April 23rd the bud was free. Neither individual showed the least sign of rupture; the base of the bud was definitely contoured before separation took place. This, therefore, is not equivalent to the laceration described by Andres, where the fragment is either torn away, or is detached by degeneration of the intermediate tissue.

At least eighteen days, in all probability longer, were consumed in completing the process. The bud possessed one siphonoglyph and six and one-half pairs of complete mesenteries.

On May 2nd, a slight constriction was observed between a second polyp and its marginal bud, producing a lobe similar to but less pronounced than that mentioned in the first case. The foot disk was elongated in the plane passing through the two individuals. On May 6th, the mesenteries of the bud, as indicated on the foot disk, radiated around the oral-aboral axis. Three only belonged also to the parent. No further change has been noted.

(*b.*) *Budding in the Œsophageal Region.*—Six cases of this mode of monogenesis have been dissected. The earliest stages have not as yet been obtained. The advanced stages appear at first sight identical with cases of unequal fission; but it may be seen in an external examination of a typical specimen that the mesenteries of the bud are continuous with those of the parent. This continuity demonstrates that this is a case of budding and not fission; since the two sets of mesenteries of two individuals formed by the latter process are almost totally independent of each other (fig. 9).

Upon dissection it was found that three pairs (1, 2, 3) of complete mesenteries of the parent (seen in cross section in fig. 10*a*) and all the incomplete mesenteries included between them, enter the bud *B*. The three pairs of complete mesenteries form the six pairs (1, 2, 3, 1′, 2′, 3′,) of complete mesenteries of the bud (seen in cross section in fig. 10*b*). Pairs 1 and 3 are bent sharply from their courses in entering the bud. One member of pair 3 does not reach the œsophagus of the parent just below the œsophagus of the bud, which accounts for the imperfect pair 3′ in the bud. A ring of stomata pierces the mesenteries around the mouth of the bud (fig. 10*c*). Neither the siphonoglyph of the parent nor the corresponding pair of directives (*D*, fig. 10*a*) enter the bud, where no such structures were seen. When formed they must arise independently of those of the parent. The two œsophagi, however, are in communication, and probably have been from the first.

In another instance, the siphonoglyph of the parent has been drawn into the bud. Figure 11*a* shows the parent and bud, each sectioned through the œsophagus. The parent has two siphonoglyphs, as indicated by the two pairs of directives *D* and *D′*. Of these, pair *D′* alone enters the bud, forming pairs *d* and *d′*. The distortion of the directives which results is accompanied by a corresponding distortion of the siphonoglyph (fig. 11*b*). Here the observer is supposed to be looking through the mouth of the bud from within the œsophagus of the parent; *s*, *s* indicate the siphonoglyph of the parent; *e*, *e* the edges of a cut across the œsophagus of the parent and longitudinally to the œsophagus of the bud, reaching the mouth of the latter; *r* is a prominent ridge dividing the siphonoglyph into an oral and an aboral portion and extending to the mouth of the bud. The median groove of each portion reaches the mouth margin distinct from the dividing ridge. This disposition of the siphonoglyphs, side by side, is unique in my experience.

Of the six polyps dissected, one of which presented two œsophageal buds, the parental siphonoglyph in but three (43 per cent.) entered the corresponding buds. It seems highly probable, therefore, that the position of the bud bears no necessary relation to the siphonoglyph nor the greater mouth axis of the parent. For since the base of any bud may include the mesenteries comprised in about one-half the circumference of the parent, one should expect to find that about one-half of the number of buds include the parental siphonoglyph.

In one case the siphonoglyph of the parent entered the bud accompanied by but one directive mesentery; a second directive with as yet no muscle band apparent was completing the pair in the bud.

V. Colonies of Three and Four Individuals.

Four instances of the former and one of the latter have been found. Of the former, three have arisen, each by two divisions in planes perpendicular to each other, the second division affecting but one of the two individuals formed by the first; the method of formation of the fourth is doubtful. The colony of four individuals has been formed as follows: *A* (fig. 12*a*) is the original polyp, shown diagrammatically. *B* has arisen as a bud upon *A*, directly opposite to the one siphonoglyph. *C* and *D* arose as one bud upon *A*, at a lower level, this bud dividing later into the definitive individuals which have a common oral disk. Figure 12*b* represents a section of the column at the level *xy*. Figure 12*c* represents a section through the œsophageal region of *C* and *D*, to show the arrangement of their mesenteries. Mesenteries 1, 2, 3, 4, 6, 7, 8 (fig. 12*b*) appear in *C–D* (fig. 12*c*). Pair 3–4 has divided, orally to *C–D*, one mesentery going to each œsophagus; while aborally to *C–D*, both mesenteries (3′–4′) are joined to *C*. This irregularity is correlated with the twist the bud *C–D* has suffered in the course of its division, for the inner ends of the œsophagi of *C–D* are in a line at right angles to that connecting their mouths. A further irregularity consists in the behavior of mesentery 8, which in *D* is incomplete orally, complete aborally. Also mesentery 5 does not enter the bud, although its mate, 6, incomplete in the parent, forms a single complete mesentery in *D*. And again, the incomplete mesentery 7, unpaired in the parent, forms two complete mesenteries in *D*. No directives nor siphonoglyphs could be seen in *B*, *C*, and *D*.

The formation of complete mesenteries in the bud from incomplete mesenteries in the parent is again seen in fig. 11*a*, where pair *c* is formed from the incomplete pair immediately above it in the parent.

These colonies have manifestly no definite architecture such as is possessed by *Amphihelia* and other of the Madreporaria. Whether the great diversity of methods of asexual reproduction in *Metridium* indicates a decline from a former widespread colonial habit, future investigations must decide. The percentage of monogenetic polyps is too small to make it probable that monogenesis assists *Metridium* in its struggle for existence. Nor does it seem more probable that, with the possible exception of basal fragmentation, it can be accounted for on purely physiological grounds.

Parker, 1897, has suggested the possibility that the monoglyphic and diglyphic types of *Metridium* may be of the value of varieties, "the products, one of the sexual, the other of the asexual mode of reproduction." My observations lead to an opposite conclusion. Both monoglyphic and diglyphic polyps reproduce by fission; and both may result from fission (figs. 3–7). Further, a bud from the œsophageal region may possess either one or two siphonoglyphs. One bud produced upon the foot disk had, at the time of liberation, but one siphonoglyph. Again, as has already been mentioned, two buds were found to have arisen independently from a single basal fragment: the one is monoglyphic, the other diglyphic. There can be little doubt, then, that the monoglyphic and diglyphic types are not of the value of varieties; such variation is not correlated with the process of asexual reproduction.

VI. SUMMARY.

Monogenesis is a well established process in *Metridium fimbriatum;* longitudinal fission, laceration, and budding from œsophageal and foot regions occur. Monogenous individuals may be sexually mature.

The plane of division tends to pass through at least one siphonoglyph. There is no apparent relation between the process of division and the number and position of the mesenteries.

Laceration may be due to unfavorable environmental conditions. It may occur in dividing polyps.

Buds arise from the œsophageal and foot regions. An œsophageal bud may occupy any position relatively to the siphonoglyph of the parent, and its siphonoglyph may be independent of that of the parent.

Both budding and fission may occur in the same colony.

Variation in the number of siphonoglyphs is not correlated with asexual reproduction. The monoglyphic and diglyphic types are not of the value of varieties.

That identical structures arise from quite different sources by different processes is significant.

It is hoped in a future paper to extend these observations and add others on the origin and histogenesis of the bud, rate of fission and bud formation, relation of budding to fission, etc.

This investigation was undertaken at the suggestion of Professor W. E. Ritter, to whom I am further indebted for many helpful counsels.

ZOOLOGICAL LABORATORY, UNIVERSITY OF CALIFORNIA,
BERKELEY, CALIFORNIA,
July 1, 1898.

BIBLIOGRAPHY.

1865. **AGASSIZ, E. C. AND A.** Seaside Studies in Natural History, p. 7.

1882. **ANDRES, A.** Intorno alla Scissiparita della Attinie. *Mitth. St. Neap.*, Bd. III.

1884. ———Le Attinie. *Fauna und Flora des Golfes von Neapel.*, Bd. IX.

1888. **BLOCHMANN AND HILGER.** Ueber Gonactinia prolifera Sars, eine durch Quertheilung sich vermehrende Actinie. *Morph. Jahrb.*, Bd. XIII, p. 385.

1775. **DICQUEMARE, J. F.** A second Essay on the Natural History of Sea Anemones. *Phil. Trans.*, Vol. LXV.

1777. ———A Third Essay on the Natural History of Sea Anemones. *Phil. Trans.*, Vol. LXVII.

1858. **MCCRADY, J.** Instance of Incomplete Longitudinal Fission in Actinia cavernosa. *Proc. Elliot Soc. S. C.*, Vol. I, p. 275.

1889. **MCMURRICH, J. P.** The Actiniaria of the Bahama Islands. *Journ. of Morph.*, Vol. III, p. 1.

1897. ———Contributions on the Morphology of the Actinozoa.—IV. On Some Irregularities in the Number of Directive Mesenteries in Hexactiniæ. *Zool. Bull.*, Vol. I, No. 3, p. 115.

1897. **PARKER, G. H.** Mesenteries and Siphonoglyphs in Metridium marginatum M. Ed. *Bull. Harv. Mus.*, Vol. XXX, No. 5.

1872. **SEMPER, C.** Ueber Generationswechsel bei den Steincorallen. *Zeit. f. Wiss. Zool.*, Bd. XXII, p. 235.

1859. **MRS. THYNNE.** On the Increase of Madrepores. *Ann. & Mag. Nat. Hist.*, 3d Ser., Vol. III, p. 449.

1868. **VERRILL, A. E.** Notes on Radiata in the Museum at Yale College.—No. 6. Review of the Corals and Polyps of the West Coast of America. *Trans. Conn. Ac.*, Vol. I, p. 377.

EXPLANATION OF PLATE XXI.

Fig. 1. Cross section through the œsophageal region of a polyp in process of approximately equal division. *D*, *D′*, directives.

Fig. 2. Single case of transverse division of the mouth; surface view.

Fig. 3. Three sections through the œsophageal region of a dividing polyp, to show the oral-aboral longitudinal division of the siphonoglyph.

Fig. 4. Two sections through the œsophageal region of a diglyphic polyp, the plane of division passing through one siphonoglyph.

Fig. 5. Similar to fig. 4; division of the œsophagus completed.

Fig. 6. Probably a diglyphic polyp originally, the plane of division having passed through both siphonoglyphs.

Fig. 7. A colony of three individuals, sectioned through the œsophageal region of each individual.

Fig. 8. Section through the œsophageal region of a dividing diglyphic polyp.

Fig. 9. Oral surface-view of the angle between two polyps—*A* and *B*—formed by division; the lines indicate the bases of the mesenteries seen through the transparent wall.

Fig. 10. A typical bud. 10*a*, cross section of the parent above the bud (indicated at *B*); 10*b*, cross section of the bud; 10*c*, indicates diagrammatically the relation of the bud to the parent; both seen in profile.

Fig. 11. Diglyphic polyp with bud. 11*a* shows cross sections of the parent and bud. *D*, *D′*, directives of the parent; *d*, *d′*, directives of the bud; *c*, pair of complete mesenteries derived from an incomplete pair just above it in the parent. 11*b*, looking through the mouth of the bud from within the œsophagus of the parent; *s*, *s*, siphonoglyph of parent; *r*, ridge dividing siphonoglyph *s* transversely into two portions; *e*, *e*, edges of a cut across the œsophagus of the parent to the mouth of the bud.

Fig. 12. Colony of four individuals. 12*a*, *A*, parent; *B*, bud on *A*; *C*, *D*, individuals formed by division of a second bud on *A*; 12*b*, cross section of *A*, at the level of *xy*; 12*c*, cross section of *C*, *D*; corresponding numbers indicate corresponding mesenteries in these two sections.

PUBLICATIONS OF THE ACADEMY.

Continued.

PROCEEDINGS (OCTAVO).

FIRST SERIES.

Vol. I (1854-1857), out of print.	
“ II (1858-1862), out of print.	
“ III (1863-1868), parts 1, 2, 3, 4 and 5, out of print.	
“ IV (1868-1872), parts 1, 2, 3, 4 and 5, part 5 out of print.	
“ V (1873-1874), parts 1, 2 and 3	$3.50
“ VI (1875)	2.00
“ VII (1876), part 1 (volume complete)	1.75

SECOND SERIES.

Vol. I (1888), parts 1 and 2	$3.50
“ II (1889)	3.50
“ III (1890-1892), parts 1 and 2	3.50
“ IV (1893-1894), parts 1 and 2	3.50
“ V (1895), parts 1 and 2	5.00
“ VI (1896)	4.50

THIRD SERIES.

Zoology, Vol. I, No. 1—Plasmocytes; the Survival of the Centrosomes and Archoplasm of the Nucleated Erythrocytes, as Free and Independent Elements in the Blood of Batrachoseps attenuatus Esch. By Gustav Eisen, Ph. D.	$1.00
Zoology, Vol. I, No. 2—Diemyctylus torosus; The Life-History and Habits of the Pacific Coast Newt. By William E. Ritter	.50
Zoology, Vol. I, No. 3—Scientific Names of Latin and Greek Derivation. By Walter Miller	.35
Zoology, Vol. I, No. 4—A Genus of Maritime Dolichopodidæ New to America. By William Morton Wheeler	.10
Zoology, Vol. I, No. 5—A Preliminary Account of the Marine Annelids of the Pacific Coast, with Descriptions of New Species. By Herbert P. Johnson, Ph. D	.50
Zoology, Vol. I, No. 6—Description of a Species of Fish (Mitsukurina owstoni) from Japan, the Type of a Distinct Family of Lamnoid Sharks. By David Starr Jordan	.25
Zoology, Vol. I, No. 7—Arachnida from Baja California and Other Parts of Mexico. By Nathan Banks	1.00
Zoology, Vol. I, No. 8—The Anatomy of Chelyosoma Productum Stimpson. By Frank Watts Bancroft	.50
Zoology, Vol. I, No. 9—The Gordiacea of Certain American Collections, with particular reference to the North American Fauna.—II. By Thomas H. Montgomery Jr., Ph. D.	.25
Zoology, Vol. I, No. 10—Observations on Monogenesis in Metridium. By Harry Beal Torrey	.25
Geology, Vol. I, No. 1—The Geology of Santa Catalina Island. By William Sidney Tangier Smith	.50
Geology, Vol. I, No. 2—The Submerged Valleys of the Coast of California, U. S. A., and of Lower California, Mexico. By George Davidson	.50
Geology, Vol. I, No. 3—The Development of Glyphioceras and the Phylogeny of the Glyphioceratidæ. By James Perrin Smith.	.35
Geology, Vol. 1, No. 4—The Development of Lytoceras and Phylloceras. By James Perrin Smith	.25
Botany, Vol. I, No. 1—A Morphological Study of Naias and Zannichellia. By Douglas Houghton Campbell	1.00
Botany, Vol. I, No. 2—Studies in the Herbarium and the Field.—No. 1. By Alice Eastwood	25
Botany, Vol. I. No. 3—Studies in the Herbarium and the Field.—No. 2. By Alice Eastwood	.50
Botany, Vol. I. No. 4—Phycological Memoirs. By De Alton Saunders.	.75
Mathematical-Physical, Vol. I. No. 1—On Rational Quadratic Transformations. By M. W. Haskell	.35
Mathematical-Physical, Vol. I. No. 2—The Quadratic Cremona Transformation. By Leonard E. Dickson	
Mathematical-Physical, Vol. I, No. 3—On Curvilinear Asymptotes. By M. W. Haskell	
Mathematical-Physical, Vol. I, No. 4—Systems of Simple Groups derived from the Orthogonal Group. By Leonard E. Dickson	.25

All subscriptions, applications for exchanges, and inquiries concerning the publications should be addressed to

J. O'B. GUNN,
Corresponding Secretary,
California Academy of Sciences,
San Francisco, California.